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THE HISTORY AND PRINCIPLES OF GEOLOGY, AND ITS AIM.

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From the earliest times the structure of the earth has been an object of interest to man, not merely on account of the useful materials he obtained from its rocky formation, but also for the curiosity awakened by strange objects it presented to his notice. The south and west of Asia, and much of the country bordering the Mediterranean, were particularly favorable for directing attention to geological phenomena. Earthquakes were of frequent occurrence, changing the relative positions of sea and land. Volcanoes were seen in eruption, adding layers of molten rock to those of sand and mud filled with the shells of the ocean. The strata in the hills abounded in evidences of similar collections of vegetable and marine life far removed from access of the sea.

The structure of the earth, however, received but little attention previous to the 7th century, B. C. The extent of the surface known was limited, and the changes upon it were not so rapid as to excite special attention. The ancient Hebrews, in the time of Solomon (1015 B. C.), prosecuted their voyages through the Straits of Babelmandeb into the Indian Ocean, bringing home the produce of the tropical regions; while the ships sent westward to the Atlantic returned with tin, silver, lead and other metalic products of Spain and Great Britian.

The earliest idea formed of the earth seems to have been that it was a flat circular disk, surrounded on all sides by water, and covered with the heavens as with a canopy, even philosophers looked upon the earth as a disk swimming upon the water. Homer (800 B. C.) regarded the earth as a flat circle surrounded by mysterious waters. The nations that were upon its border were called Cimmerians, and were supposed to live in perpetual darkness.

As the ancients slowly gained a knowledge of the country surrounding their provinces through commercial intercourse, wars, and the search for knowledge, they were undoubtedly struck with the differences of the topography and formations. Thus geology is undoubtedly the outgrowth of geographical knowledge.

The 7th and 6th centuries B. C. were remarkable for great advance in the knowledge of the form and extent of the earth.

Their first discoveries were probably made by the Phœnicians. Their investigations were along the shores of the Mediterranean, and passing through the Straits of Gibraltar, they extended their researches into Spain and Africa and the Canaries.

Pythagoras (583 B. C.) observed the phenomena that were then attending the surface of the earth, and proposed theories for explaining the changes that had taken place in geological time. He held that in addition to volcanic action, the changes in the level of the sea and land were due to the retiring of the sea.

Aristotle (384 B. C.) recognized the interchange constantly taking place between land and sea by the action of running water and of earthquakes, and remarked " how little man can perceive in the short space of his life of operations extending through eternity of time."

Geographical knowledge was greatly advanced by the conquest of Alexander the Great (356 B. C.), in making known

Persia, and science was advanced by sending out expeditions to explore and survey the various provinces he had conquered. The Greeks he sent out, and also those who accompanied him, were critical observers and carefully described the products and aspects of the country, and made collections of all that was interesting in regard to the organic and inorganic products.

Ptolemy (323 B. C.) discovered Abyssinia and navigated the Arabian Sea, and Silineus (306 B. C.) ascended the Ganges to Batna and extended his expedition to the Indus.

It was the military genius of the Romans which led to the survey of nearly all Europe, and large tracts of Asia and Africa. In the height of their power they had surveyed and explored all the coast of the Mediterranean, Italy, the Balkan peninsula, Spain, Gaul, West Germany and Britain, and their practical genius led them to the study of the natural resources of every province and state brought under their sway.

Eratosthenes (276 B. C.) considered the world to be a sphere revolving with its surrounding atmosphere on one and the same axis and having one center. His theories were perfected by Hipparchas (160 B. C.). He attempted to catalogue the stars and to fix their relative position, and he applied to the determining of every point on the surface the same rule he introduced in the arrangement of the constellation.

Strabo (60 B. C.) noticed the rise and fall of the tide, and maintained that the *land* changed its level and not the *sea*, and that such changes happened more easily to the land beneath the sea on account of its humidity.

Ptolemy (150 A. D.) was the first scientific geographer. He followed the principles of Hipparchas, which had been neglected during the two centuries and a half since his time, even by Strabo and Pliny. In Ptolemy's work is found for the first time the mathematical principle of the construction of maps, as well as several projections of the earth's surface.

After the great achievements of Ptolemy to the 13th century, the cultivation of the physical sciences was neglected. In the 10th century Avicenna, Almar, and other Arabian writers commented on the works of the Romans, but added little of their own.

From the 13th to the 16th century, astronomy, travels, and commercial interests occupied the attention of the different nations, but geology did not appear as a separate science until in Italy in the 16th century. It began by being a record of observed facts. This was not enough, however, for it did not satisfy the demand as to how the phenomena were produced. High above sea level, and far inland, imbedded in solid rock, were found fossils. At the outset it was unfortunately linked to the belief that they were relics of the Noachean deluge. Some held that they were the result of the formation of a fatty matter, or of terrestrial exhalations or of the influence of the heavenly bodies, or that they were merely concreations, or sports of nature. The abundance of fossils in the strata of the Apennine range could not fail to arrest attention and excite inquiries. Leonardo da Vinci (1519) and Fracostaro, whose attention was engaged by the multitude of curious petrifactions which were brought to light in 1517 on the mountains of Verona in quarrying rock for repairing the city, had sound views, and showed the inadequacy of the terrestrial deluge to collect marine fossils.

Collections were made for museums, that of Canceolarius, at Verona being the most famous. Descriptive catalogues of these collections were published.

Only a few held that they were the remains of animals. Palissy in 1580, was the first who dared to assert in Paris that fossil remains once belonged to marine animals. The question was naturally asked "How came they there?" The result of investigation showed that the rocks must have accumulated around them, and hence could not always have been as they were found and that the arrangement must have changed since they were formed. This brought about the study of the construction of the earth.

Their chief objects were the examination of the materials out of which the solid framework of the earth was built, and the determination of their chemical composition, physical properties, manner of occurrence, and their characteristics. Thus they started out with the idea that rocks were made through secondary causes.

Steno (1669) observed a succession in the strata, and proposed the theory that there were rocks older than the fossiliferous strata in which organic remains occur. He also distinguished between marine and fluvialite formations. He also published his work "De solido intra solidum naturalites contento," in which he proves the identity of the fossil teeth found in Tuscany with those of living sharks.

Scilla, in 1670, published a treatise on the fossils of Calabria, and maintained the organic nature of fossil shells. But both Steno and Scilla referred their occurrence to the Noachean deluge.

In England the diluvialists were busy forming idle theories to give plausibility to their creed, that the Noachean deluge was the cause of all the past changes on the earth's surface. Differing somewhat in detail, they all agreed in the notion of an interior abyss whence the waters rushed, breaking up and bursting through the crust of the earth, to cover the surface, and whither, after the deluge, they returned. Such absurd notions greatly hindered the advance of science.

Leibnitz (1680) proposed the bold theory that the earth was originally in a molten state from heat, and that the primary rocks were formed by the cooling of the surface, which also produced the primeval ocean by condensing the surrounding vapors. The sedimentary strata, he held, resulted from the subsiding of the waters that had been put in motion from the collapse of the crust on the cooling and contracting nucleus.

Burnet (1680) published his "Sacred Theory of the Earth," and it received great applause. It was written in ignorance of the facts of the earth's structure, and was an ingenious speculation. It abounds in sublime and poetical conceptions in language of extraordinary eloquence. In 1692 he published a work which treated of the Mosaic Fall as an allegory.

Lister sent to the Royal Society, in 1683, a proposal for maps of salts and minerals. He was the first to recognize the arrangement of the earth's materials in strata, continuous over large areas, and resembling each other in different countries.

Hooke (1688) and Ray (1690), differing as much from Burnet as from Leibnitz, considered the essential condition of the globe to be one of change, and that the forces now in action would, if allowed sufficient time, produce changes as great as those of geological time. Hooke published a "Discourse on Earthquakes," which contains the most philosophical view of the time respecting the notions of fossils and the effect of earthquakes in raising up the bed of the sea. Woodward perceived that the lines of outcrops of the strata were parallel with the ranges of mountains. He formed, about the year 1695, a collection of specimens which he systematically arranged and gave to the University of Cambridge.

They were followed in the same direction by Vallismeme (1720), Moro (1740,) Buffon (1749), Lehman (1756), and Fuchsel (1773), each contributing something additional, and advanced the most philosophical views yet presented respecting the fossiliferous strata. The first two made observations throughout Italy and the Alps. Moro endeavored to make the production of strata correspond in time with the account of the creation of the world in six days.

Buffon published his "Natural History," in which he advanced views respecting the formation and modification of mountains and valleys by the action of water.

Geology did not begin to assume the rank of an important science until its application to the practical purposes of mining and agriculture was first pointed out in 1780 by Werner, Prof. of Mineralogy in the School of Mines at Freiberg in Saxony. He greatly advanced the science by establishing the superposition of certain groups, by giving a system and names. He had very crude ideas regarding the origin of the strata. He supposed that the various formations were precipitated over the earth in succession from a chaotic fluid ; even the igneous rocks he held to be chemical precipitations from the waters.

Thus we see that the history of geology has been a record of failures, and it was not until Hutton (1788), rejecting all theories as to the beginning of the world returned to the opinions of Pythagoras and Ray. He pointed out that geologists must study the *present* if they would learn of the *past*; and he labored to show that the forces now in operation are capable of forming rocks and of bringing about the changes that have occurred on the earth. He held that the strata which now compose the continents were once beneath the sea, and were formed out of the waste of preëxisting continents by the action of the same forces which are now destroying even the hardest rocks. Hutton was the kind of man the science had so long been in need of, and by his teaching geologists were at last started on the only path that could possibly lead them to truth. He drove out at once and forever the imaginary agencies which the early geologists had been so ready to have recourse to, and laid down the principle that in geological speculation "no powers are to be employed that are not natural to the globe, no actions to be admitted of except those of which we know the principle, and no extraordinary events to be alleged in order to explain a common appearance." He occupied himself mainly studying the changes that are now taking place on the earth's surface, and the means by which they were brought about, and in demonstrating the fact that the changes that had happened during the past periods of the earth's history were of the same kind and due to the same causes as those now going on.

The determination of the order of the strata, and the grouping of them in chronological order, were begun by Lehman (1756) and carried on by Fuchsel (1773), Pallas (1785) and Werner (1789). Smith made the most important contribution to this subject when, in 1790, he published his *Tabular View of the British Strata.* He showed their superposition and characterized the different groups by their peculiar fossils.

(*To be continued.*)